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DIVERGENCE AND CONVERGENCE IN FISHES.[1]

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ILLUSTRATIONS BY CLARENCE KENNEDY.

The struggle for existence with the biological environment as the result of the geometric rate of increase tends to divergence in habit and form. It tends to divergence in habit and form by preserving variants whenever such possess a character diverging sufficiently in amount to give the variant a personal advantage over his fellows — always provided the divergent character is transmissible.

Whether we call the diverging individuals variants in the old sense, or mutants in the new, it is to the selection of those among them best adapted to utilize the foods of various sorts, to escape the enemies of various sorts and to leave others similar to them in their place when they die that we owe the specific divergence in structure, shape, color, food-habits and breeding-habits of a given family — say the American characins. The entire process tends to the divergence and multiplicity of species.

The characins are a family of fresh-water fishes that, in America, range from the border of the United States to some distance south of Buenos Ayres. They form about one third of the entire South American fresh-water fauna, and have diverged in adaptation to diverse food, diverse habitat and diverse enemies to fill nearly every niche open to fishes. The ends of the three lines of adaptation to different food give us mud-eating forms, with long intestinal tract and no teeth; flesh-eaters with shear-like teeth, that make bathing dangerous to life and that cut their way out of nets; and conical-toothed forms, with sharp, needle-like teeth and comparatively huge fangs. Greater diversity could

[1] Contributions from the Zoölogical Laboratory of the Indiana University, No. 64.

scarcely be imagined, and one is lead to suspect that some of the forms are over-adapted. In their divergence in form they have reached almost every conceivable shape as we shall see in a moment.

The struggle for existence with any unit of physical environment, whether there be geometric rate of increase or not, tends to convergence in habit and form. There is no more striking instance of this than the acceptance of the annual, or deciduous, habit of most of the plants inhabiting the temperate zones with their seasonal changes. Records of the simultaneous and similar changes in the form in the mass of species of any area during changing physical conditions are not wanting. For instance, Scott says:[1]

"The steps of modernization which may be observed in following out the history of many different groups of mammals are seen to keep curiously parallel, as may be noticed, for example, in the series of skulls figured by Kowalevsky, where we find similar changes occuring in such families as the pigs, deer, antelopes, horses, elephants, etc. Indeed, one may speak with propriety of a Puerco, or Wasatch, or White River type of skull, which will be found exemplified in widely separate orders."

On some riffles of the San Juan river of Cuba I found a small fish that is very strikingly like other fishes inhabiting similar localities in the eastern United States. The former is a goby, a marine form, *Philypnus dormitator*, that has become adjusted to the conditions found about the riffles of streams; the others are darters, *Hadropterus*, belonging to an entirely different family of fresh-water fishes. The similarity of various "darters" which live on the bottom of our streams to various gobies and blennies that occupy a similar position along marine shores has repeatedly been noticed.

In the tropics live many burrowing lizards and snakes. *Rhineura*, one of the lizards, lives and acts like an earthworm and so like an earthworm has it become that only a close inspection reveals its true nature. Even the chickens following the plows in Florida and Cuba are said to be taken in by the similarity of some of the burrowing lizards to earthworms.

[1] *Journ. Morphol.*, V., 365, 1891.

The characins again furnish striking illustrations. Diverging among themselves, as has been noted above, they have approached, or paralleled many members of the diverse families of North American fresh-water fishes. Our shads and fresh-water herrings have their counterparts in *Elopomorphus*, *Potamorhina* and *Psectrogaster;* our salmon are paralled by *Salminus* and *Catabasis;* our minnows are paralleled by *Tetragonopterus* and its relatives. It will take but a slight flight of the imagination to detect the striking similarity of some of the Hydrocyninæ to our gar pikes; our mullets are duplicated by *Prochilodus;* our top-minnows are mimicked by *Nannostomus*, and even our festive darters are duplicated by a member of this most remarkable family, *Characidium fasciatum.*

I have elsewhere given an example of convergence under the similar conditions presented by different caves. *Troglichthys rosæ*, a blind fish of southwestern Missouri, resembles so closely *Typhlichthys subterraneus* of Kentucky that at least two naturalists, expert in detecting specific differences in fishes, had failed to distinguish them, although below the adaptive resemblances of the surface there was distinct evidence that the epigean ancestors of the two species were generically distinct.

A cave presents a "unit of environment," a little world, a microcosm, with both positive and negative characters.

1. This unit is well circumscribed and connected with the rest of the universe frequently by but a single narrow vestibule. In this vestibule we have a rapid graduation from external to internal cave conditions — a region which acts as a purgatory for all forms that would enter the elysian fields within. The majority of epigean forms never get beyond the twilight of this region.

2. The feature that distinguishes the interior of the cave is the constant absence of sunlight and all which that implies.

(*a*) The absence of all green plants and consequently the absence of all direct food-producing activity. (*b*) As a result of (*a*) all food must ultimately be imported. (*c*) As a result of (*b*) the abundance of the fauna in different caves is frequently inversely proportionate to the size of the cave, or directly to the ability of the openings to admit food to the various recesses of the different caves.

3. A feature no less striking, though varying greatly in different caves, is the constancy of the temperature — the absence of great diurnal and seasonal changes. This differs very much in different caves, and we have caves in the temperate zone in which there is always ice — in summer as well as in winter — and others in which ice never forms. This difference is due to the shape of the cave and the accessibility of outside air in winter and summer. Usually seasonal changes are very slight.

4. This unit of environment is further characterized by the relatively stationary atmosphere, the absence of rain, snow, or severe currents of air. In the deeper recesses of a cave it is rarely that an air-current is perceptible with an anemometer unless there is moving water near. In the blind-fish caves of Mitchell, Indiana, a current of air enters the cave above with the water and leaves it three quarters of a mile below with the water. In Little Bat avenue, one of the upper tiers of river channels of Mammoth Cave, there is no perceptible air-current until the top of Mammoth dome is approached, where a perceptible current enters the dome, descending to the bottom of the dome and then ascending again to leave the dome about half way up by Sparks avenue. This local air-current is caused by the cascade descending from the uppermost to the lowermost part of the dome.

Air-currents are most readily perceived at a cave's entrance and vary with the size of the opening, the size of the cave and the rapidity of barometic changes on the outside.

In a small cave air-currents are not strong about the entrance. In a large cave, such as Mammoth, where the opening is small the current may become a fierce gale if barometric changes are rapid or if the water in the cave rises rapidly. If the barometric pressure increases there will be an inflow of air and this will be proportionate to the rise of the barometer and to the size of the cave. If the barometer is falling there will be an outpour of air and the pressure on the inside or outside may be so nicely balanced that no current will be perceptible, or there may be a continued shifting of currents in or out every few moments with every slight shifting of outer atmospheric pressure not perceptible with the ordinary mercurial barometer.

5. What has gone before concerning the changes in light, heat and plant-growth in the cave in general applies to the water in a cave except that the total content of the rivers of a cave will change with comparative rapidity. With every freshet in epigean rivers there is a corresponding freshet in the subterranean streams. There must be some change in the temperature of the water in caves though the change is not at all commensurate with the changes in temperature in epigean rivers. No detailed records of water temperatures are at hand.

In an environment, such as that above described, all those differences between related species which would strike the eye, such as protective coloration, recognition marks, decorations of any sort, etc., are absent and related species tend to look alike. *Amblyopsis* and *Typhlichthys* look alike when of the same size, and it was not until after a detailed examination of many specimens that I could invariably distinguish *Lucifuga* and *Stygicola*, the Cuban blind fishes, from each other. There are two unrecorded species of *Typhlichthys*, differing from the only known species, *subterraneus*, in only a few inconspicuous respects.

Typhlichthys subterraneus has been known chiefly from Mammoth cave, the type having come from a well at Bowling Green, south of Mammoth Cave. I have repeatedly taken it at Glasgow, Kentucky. It has erroneously been recorded from Missouri and Indiana, but is confined to the region south of the Ohio and east of the Mississippi.

A number of years ago a single specimen of *Typhlichthys* was sent to Indiana University from Corydon, Ind., and it was referred to *subterraneus*. Every endeavor to secure additional specimens has so far failed. The Corydon specimen may here be described as

Typhlichthys wyandotte Eigenmann, sp. nov.*

The single specimen taken from north of the Ohio River, from a well near Corydon, Indiana, differs slightly from those south of the Ohio, being somewhat more slender. The Corydon specimen is 42 mm. in length from the tip of the snout to the base of the caudal, and other measurements are as follows: Head in length of body to base of caudal, 3⅔; width of head in length of body 6½, 1⅔ in its own length; distance from posterior

*This specimen has been recorded as *Typhlichthys subterraneus* Eigenmann, Proceedings Indiana Academy of Science, 1898 for 1897, 230 (Corydon, Indiana).

margin of the skull to the front of the first dorsal ray, 16 mm. ; front of dorsal to middle ray of the caudal, 17 mm. First anal ray nearer base of middle caudal ray than the anus. Specimens from about Mammoth Cave 42 mm. long, measure as follows : Head 3 to 3¼ in length of body ; width

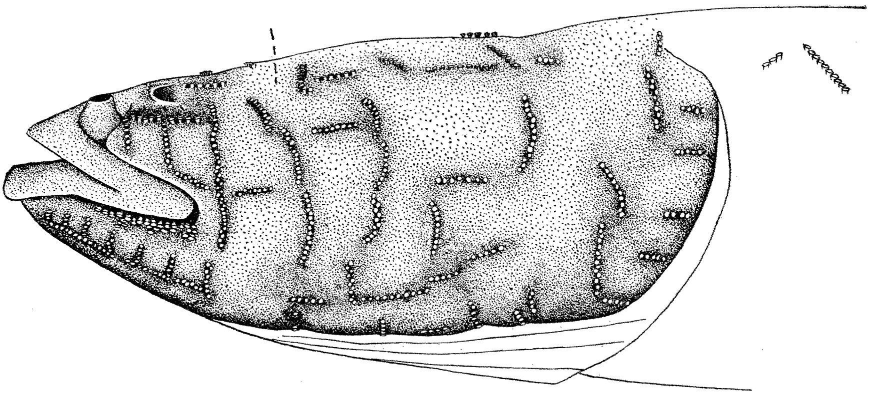

FIG. 1. Side view of the head of a *Typhlichthys subterraneus.*

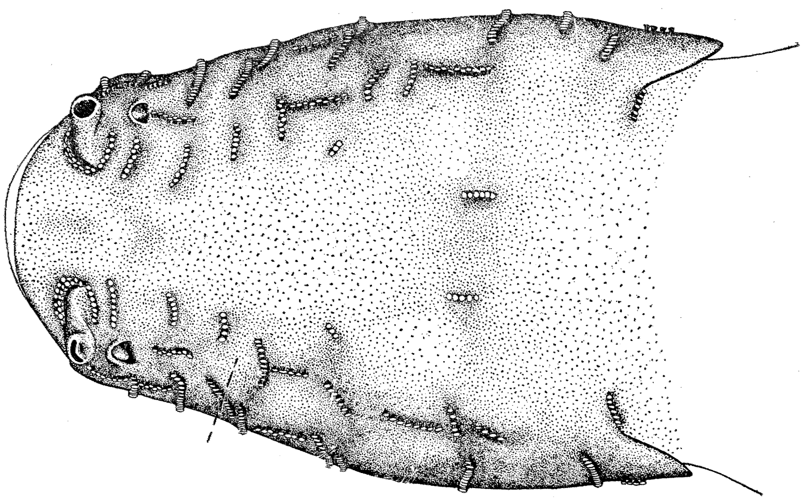

FIG. 2. Dorsal view of the same.

of head in length of body, 5, $1\frac{1}{2}$ to $1\frac{3}{5}$ in its own length ; distance from the base of the skull to the first dorsal, 15 mm. ; front of dorsal to middle ray of caudal, 17½ mm. First anal ray about equidistant from the base of the middle caudal ray and the anus.

The second new species may be described as

Typhlichthys osborni * Eigenmann, sp. nov.

November 29 to December 2 a large number of *Typhlichthys* were obtained. Five from Mitchell's cave at Glasgow representing *subterraneus*

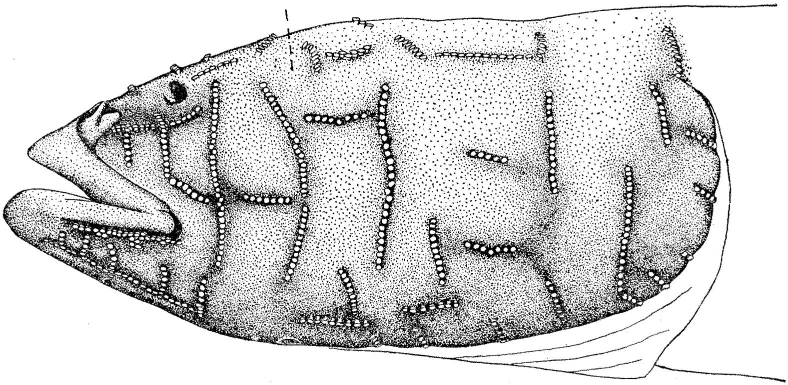

FIG. 3. Side view of the head of a *Typhlichthys osborni.*

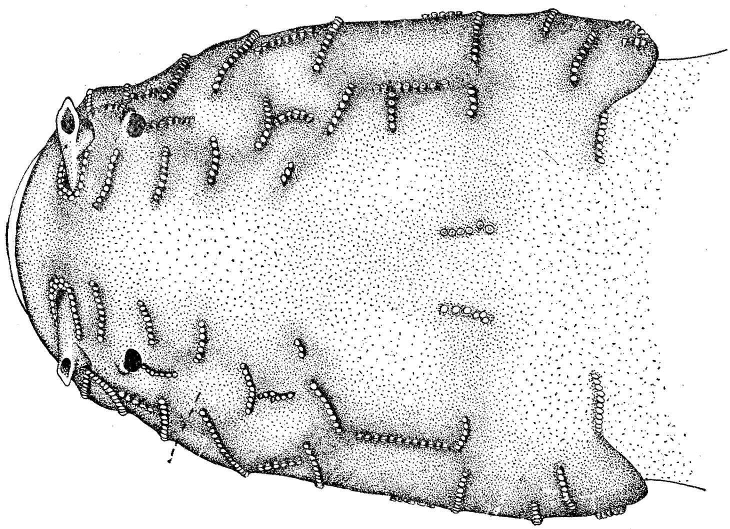

FIG. 4. Dorsal view of the same.

All the figures show the tactile organs of the head and their mode of arrangement. The general outlines and the arrangement of the tactile organs are from camera sketches, the number of tactile organs are from actual counts. The differences in the eye region can be but faintly indicated in the drawings.

and forty-two from Horse Cave. Both these localities are on the L. & N. R. R., not far from the Mammoth Cave. The specimens from the two locali-

* To Henry Fairfield Osborn of the American Museum of Natural History in recognition of his interest in the zoölogy of the interior of the United States.

ties differ strikingly while alive. In the Horse Cave specimens the head is pointed, the cheeks puffed, the eye spaces show conspicuously as white spots and bulge out like a rounded dome, the fatty masses above and below on caudal peduncle are conspicuous and white. They measure 20–50 mm.

The specimens from Glasgow have the eye-spaces inconspicuous, not protruding, and the caudal fatty masses are inconspicuous. The largest specimen from Horse Cave agrees with these in most respects.

These specimens were put into two aquaria with siphon overflow of 5 and 10 mm., into a common central aquarium. The specimens readily moved through the siphons from one to the other. One specimen had traversed both siphons in between two and three hours.

The Horse Cave specimens stay under leaves, etc., in their aquarium. Those from Glasgow swim about more.

The characters of the three known species of *Typhlichthys* may be summarized as follows:

(*a*) Width of head more than 6 in the length to base of caudal; length of head $3\frac{2}{3}$; first anal ray nearer base of middle caudal ray than to the anus...*wyandotte*.

(*aa*) Width of head 5 in the length to base of caudal; length of head $3-3\frac{2}{5}$; orbital fat-mass elongate, inconspicuous in life, not projecting; cheeks little swollen; eye on an average .16 mm. in diameter, the smallest measures .14 mm. *subterraneus*.

(*aaa*) Width of head $4\frac{1}{2}$ in the length to base of caudal; length of head $3\frac{1}{6}$; orbital fat-mass round and very conspicuous in life, projecting dome-shaped beyond contour of surrounding parts; cheeks much swollen; eye less than .10 mm. in diameter..*osborni*.